Information Science and Technology Center Seminar

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"Group Lifting Structures for Wavelet Transforms and Multirate Filter Banks"

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3:00 - 4:30 PM
TA-3, Bldg. 1690, Room 102 (CNLS Conference Room)

Abstract: Wavelet transforms are time-frequency (or space-wavenumber) signal decompositions with good phase-space localization properties and fast numerical algorithms. Lifting was introduced by Sweldens as a method for synthesizing "nice" wavelet transforms from simple examples. In digital signal processing lifting can be interpreted via factorization theory for invertible matrix polynomials. Multirate filter banks, the digital realizations of wavelet transforms, are best described in terms of transfer matrices, and lifting is nothing more than a particular type of elementary matrix decomposition. Lifting is important in both the theory and application of wavelets because of the universality of elementary matrix decompositions and the efficiency of lifting-based numerical methods. For instance, the ISO JPEG2000 image compression standard specifies wavelet transforms in terms of lifting.

Group lifting structures were introduced by the speaker to exploit the group-theoretic structure of invertible matrix polynomials. Group lifting structures are developed for linear phase lifting factorizations of both whole- and half-sample symmetric linear phase filter banks, which correspond to wavelet bases with symmetric or antisymmetric mother wavelets. In particular, whole-sample symmetric group lifting structures cover the specifications for whole-sample symmetric wavelet transforms in JPEG2000. To illustrate the strength of the group-theoretic approach, we address the non-uniqueness of lifting factorizations, an issue first raised by Daubechies and Sweldens. With no constraints, elementary matrix decompositions (including lifting factorizations) are highly non-unique, but when certain hypotheses are satisfied the factorizations generated by a group lifting structure are unique, a rather surprising result in linear algebra. This implies, e.g., that there is one and only one way to factor a whole-sample symmetric wavelet transform into JPEG2000-compliant lifting factors. A major objective of this research is to develop a group-theoretic framework for numerical filter bank design, a goal motivated by the fact that invertible filter banks do not form vector spaces.

Biography: Chris Brislawn is a current Laboratory employee and a member of the Computer, Computational, and Statistical Sciences Division's Information Sciences Group. He received his B.S. in 1982 from Harvey Mudd College and Ph.D. in 1988 from the University of Colorado. His research interests include digital filtering, communications coding, and statistical signal processing. As a LANL postdoc he coauthored the Wavelet/Scalar Quantization Specification for digitized fingerprints with the FBI, and he later led the LANL team that participated in writing the ISO JPEG2000 standard. Brislawn coauthored the proposal to create JPEG2000 Part 10 (Extensions for Three-Dimensional Data), serving as the first editor of Part 10. In 2007-08 he represented LANL on the Motion Imagery Standards Board for the National Geospatial Intelligence Agency. He has mentored 15 students and 4 postdocs at LANL and cosupervised one Ph.D. dissertation for the University of Texas. Brislawn is a Senior Member of the IEEE and a member of the American Mathematical Society.

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